

Engineering & Maintenance Concepts for ILC Remote Operations

*A Conceptual Model for Engineering Development,
Commissioning and Sustaining Engineering Support of
Remote Operations and Maintenance*

R.S. Larsen, SLAC
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1. Introduction

The task of the Engineering Designs for Remote Operations Working Group was to discuss the question of how technical “experts” would be used in a GAN remote operations model. For purposes of this discussion the assumed model is:

- ❑ Collaborating partners will agree to fund, design, build, commission and operate major systems of the machine. Funding of operations and support of specific contracted subsystems will continue into the indefinite future.
- ❑ Multiple control centers remote from the site will take turns operating the machine as an important part of the ownership model.
- ❑ Only the minimum number of experts will reside at the machine site, leading to questions of expert support requirements.
- ❑ Experimental detectors presumably will follow a similar model.

This note is intended not to summarize all the discussions of remote operation, but to open a serious discussion among design, engineering and operations experts of how the GAN model impacts the broad spectrum of engineering design and operational support requirements, which in turn dictates the technical and operational management structures that must be developed.

This question of structure must be answered clearly and agreement sought among collaborators before such a model can be brought into existence, before agreements of scope of technical participation can be struck among collaborators, and possibly before funding is possible. In other words, experiments can be contrived to show technically that remote operation of an accelerator is possible; but unless that experiment incorporates a realistic operational and technical support model along with a management structure defining both lines of authority and lines of responsibility, then it is extremely limited in evaluating the GAN concept. Such a demonstration is a more difficult experiment leading toward building a template for the real collaboration.

The full GAN model of a new machine must explore all aspects of designing, building, commissioning and operating a machine built through a co-equal partnership. The remainder of this note explores some features of technical, operations and support structures needed in a viable international collaboration that were originally discussed in the WG3 Shelter Island Workshop summary.

2. Controls Team Model

Figure 1 illustrates a controls management and operations concept. The accelerator site operates with a Maintenance Operations staff and a Safety Management staff. The Maintenance staff includes sub-groups specializing in each system, but also cross-trained on

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other systems. Each sub-group leader is specially trained as a *systems* maintenance expert. To obtain maximum machine Availability, *all* subsystems will be designed as far as possible to be modular with some level of redundancy for added reliability and for very quick replacement of a failed module. This applies especially to power systems, modulators, RF components and the critical support systems of low-level RF, timing and instrumentation. Obviously these requirements must be factored into all conceptual designs as early as possible.

The Maintenance Operations group takes instructions from the current Remote Control Room (RCR) in charge. Optimizing operation of the RCRs will not be debated here; operations experts in consultation with the experimenters, machine physicists responsible for machine development and support staff will design this system. We assume that in the RCR the same functions are present as in any present control room, namely the equivalent of a Chief Operator, an on-duty Machine Physicist for machine development (MD) programs, and Accelerator Operators managing the various subsystems and operational modes of the machine.

When expert help is required, the Chief Operator or more senior person in charge if one is designated will place the call. A Systems Expert Coordinating Group with representatives from each RCR *a priori* will set up the shift coverage for on-call experts. More than one expert per shift should be available for any critical subsystem where subtle systems problems are likely to occur. These on-call experts can be located anywhere in the world, as long as they are within reach of reliable communications. The XNET Expert Network shown in the figure could minimally be a cell phone accessed from a guaranteed reliable link, but preferably the expert should have access to the web to view diagnostics and discuss the problem live with the Maintenance Operations person at on site. With wireless modems and laptops, this may be relatively easy to accomplish without requiring the expert to remain at a fixed location while on call.

A key question is how effective this support system can be in normal machine operations. Some present day operations models require the experts to be local and on-call at any time to come to the site when serious problems arise. This model will not work for GAN. Instead, one must assume that if a problem simply cannot be fixed over the remote linkage, one or more experts will need to hop an airplane to the site as quickly as possible. Thus both the accelerator site and the RCRs should be within easy reach of direct-flight air service. The total analysis of this problem again impacts machine design (e.g. redundancy and modularity) and maintenance models (e.g. ready spares for easily replaceable units or modules).

Above the “Protective Halo” of machine experts in Figure 1 is the overall Collaboration Operations Management group. This group is responsible for the smooth operation of the entire enterprise. It will develop metrics for the effectiveness of operations with the model shown, e.g. collect Reliability and Availability data for all systems and the machine as a whole, and make adjustments accordingly. Many problems will be related to inter-cultural communications and personnel management, and the problem of how to keep the remote

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Experts in close touch with the reality of an operating machine, the two really new components of a GAN versus a conventional system. Regarding the latter, the Experts will need to be involved in developing training materials and training maintenance people on an ongoing basis, and should expect to make site visits for these purposes. On-site workshops that bring the various team players together on a planned basis also will be necessary.

GAN remote control experiments should develop some version of this structural model as a test bed. A simple test of turning knobs in one remote location and operating a machine in another location is not much of a test. The test will be to actually solve problems with the remote experts isolated in a GAN-like fashion. This is not easy with present machine designs because they lack what can be called Design For Availability. However it may be possible to find an existing machine, or subsystem of a machine, that can serve as an experiment. The next requirement is to train the people in the remote location in operations enough to take over for at least a shift, with the remote Expert looking only at diagnostic information that can be obtained over the communications system.

3. Engineering Design Team Model

We now turn to the structure of a typical system design team based on the premise that there are clusters of experts for a given type of design at various laboratories and universities, and that a “final” model of a machine designed by international collaboration will attempt to involve the best people for a given discipline no matter what their affiliation. However, there is also an *ownership* model that requires the identification of a *lead laboratory* to develop each subsystem, and that match-up will depend on the machine technology and the laboratory’s expertise. In some cases a laboratory can acquire the necessary expertise with the help of other experts in the collaboration. An example is the ongoing effort by Fermilab to manufacture X-Band RF structures, a field they were not actively engaged in, but which has been already shown to be feasible because of their general expertise in manufacturing. At present we have not made a basic technology selection between a warm and a cold machine, but irregardless we can experiment with an extended model for managing collaborative R&D of mutual interest.

Figure 2 shows a basic design engineering structure that approaches a GAN model. The model begins with small collaboration teams drawn from the different Collaborator-Laboratories where experts form a subsystem task team to advance the R&D in an area of common interest. One of the “*Collaboratories*” provides the person or persons who form the lead team, which means providing special leadership expertise and/ or resources. Other team members can be drawn from other laboratories whether or not they have the potential to carry a full system engineering responsibility in future. The determination should be made on the ability for the home institution to support the personal involvement as an immediate contribution and as an opportunity for a larger involvement in future.

These sorts of teams can be formed now, and some no doubt are already functioning that

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closely resemble this model. The important aspect is to make them operate efficiently as a project team. This requires a higher structure that operates like a project, where project-engineering disciplines are brought into the mix. This can only be done when designs transition from loose concepts to prototyping and development of a realistic set of requirements. *Figure 2* shows this transition as a dotted line to a higher stage of oversight when the R&D team becomes an Integrated Engineering Team for a particular system. When this occurs several related activities will be merged into the larger team as shown by the multiple arrows entering the Integrated Engineering organizational box. Above this box, the Project Engineering Management Team will specify formal Requirements for all elements of the subsystems and the System team(s) will fully transition to the project development phase.

4. Other Project phases

A Collaboration General Management Team sits at the top level. This team manages and coordinates the entire gamut of similar teams not only for the various technical elements, but for the full range of project activities: Conceptual design, development, manufacturing, installation, system integration, testing and commissioning. It will also oversee development of all structures for future operations as discussed in the model of *Figure 1*.

5. Discussion and Conclusion

This brief discussion is intended to begin a dialog of how technical, managerial and participation models can be constructed over the full range of tasks and activities needed for a machine built as a GAN type collaboration. Before we can claim an understanding of a machine that will support a GAN model these issues need to be faced as soon as possible. The expertise for answering these questions lies with experts representing the range of technical skills needed to manage, design, build, commission and operate a next-generation accelerator. Moreover, the Availability goals for such a machine have not been clearly addressed and many technical questions of Design for Availability have not been answered. These issues affect the design specifications, the maintainability of the final product, its cost and the way in which it will be maintained. It seems crucial to begin modeling the subsystems and systems design models as soon as possible, along with the operations model. If we enter into a situation where funding is actually approved without these areas being sorted out ahead of time, and factored into the proposal, we can guarantee nasty surprises and cost overruns and other forms of management chaos. Judging from recent history, ignoring these issues indeed could lead to a major disaster.

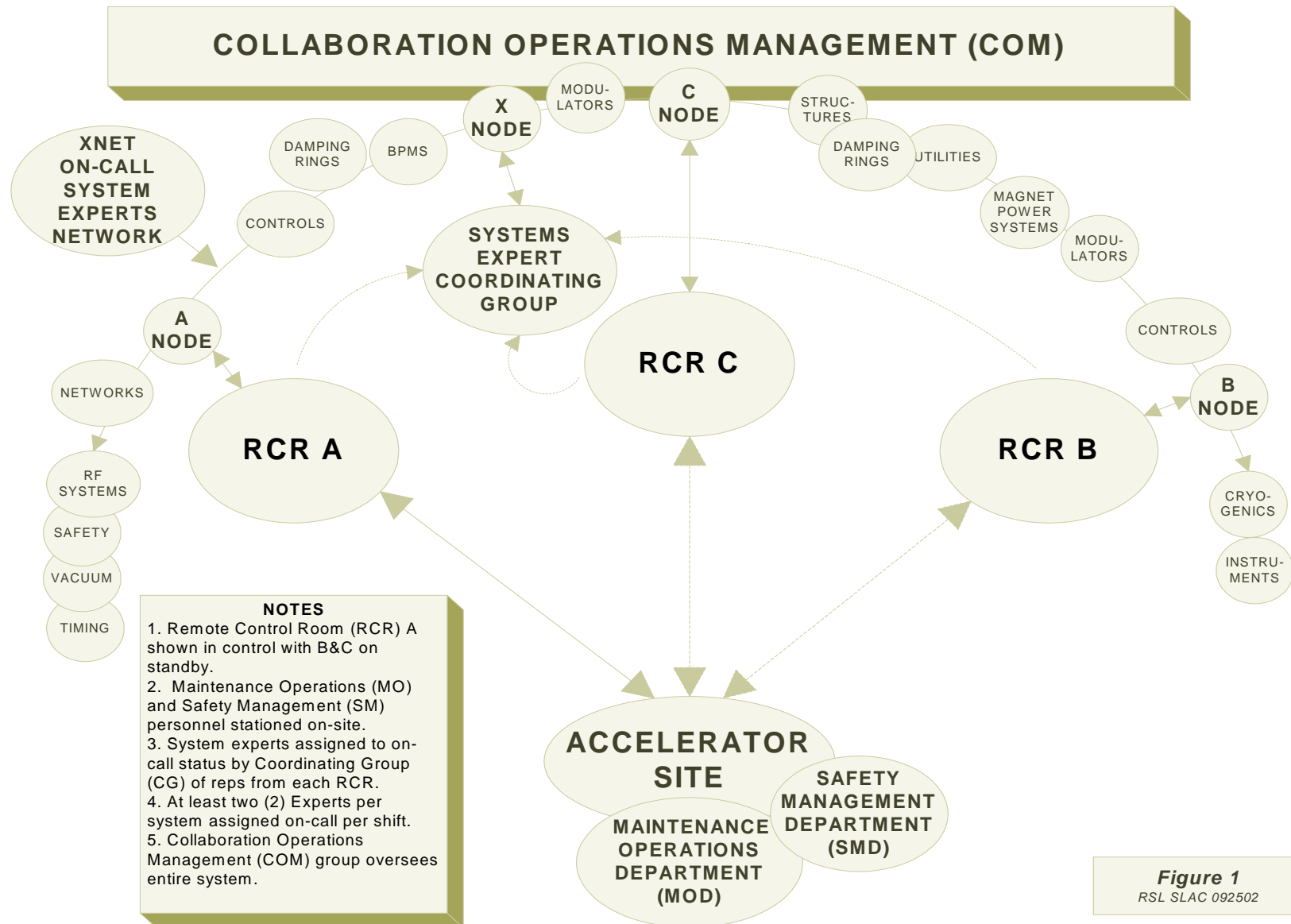
From just an Operations point of view, several issues loom large: The training of remote operations groups to a high level of competence and trustworthiness; achieving efficient handoff from one group to the next; training the on-site maintenance staff to be able to independently handle a larger range of systems and subsystems issues; and finally the difficulties associated with making remote expert help almost as effective as with the person

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present physically. Technology, better documentation, and reliance on developing Expert Systems can help with some of these issues, but much design and experimentation is necessary before it can be accurately evaluated.

Grappling with these issues now will force the community to begin the give-and-take necessary to identify the issues of designing and building a functioning shared-ownership Collaboration team. This needs to be done before any more collaborator-competitors drive any more stakes into the ground. When non-negotiable conditions become fixed in the minds of the major proponents, forming a true shared partnership and shared ownership collaboration where all parties are satisfactorily included becomes intractable both in principle and in practice.

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